ALBERTA HORTICULTURAL RESEARCH CENTER

BROOKS, ALBERTA

DISEASES OF SMALL FRUITS
IN ALBERTA

AHRC PAMPHLET 83- 1 JULY, 1983

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AGRICULTURE

DISEASES OF SMALL FRUITS IN ALBERTA

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This is a revision of AHRC Pamphlet 81-11 of the same title.
All outdated copies should be discarded.

FOREWORD

This handbook is designed to assist Alberta market gardeners and small fruit growers in the diagnosis and treatment of diseases on small fruits. This publication is not intended to be a comprehensive treatment of all of the known disease problems on small fruit crops; rather, it includes information on the major diseases likely to be encountered. In difficult or questionable situations, the opinion of a professional plant pathologist should be sought. Control recommendations, particularly those involving chemical pesticides, are subject to periodic change. Reference to pesticides in this publication is for the reader's convenience. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Additional copies of this publication can be obtained from: Library, Alberta Horticultural Research Center, Bag Service 200, Brooks, Alberta, T0J 0J0.

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GENERAL INFORMATION

NUTRIENT DEFICIENCIES

Nitrogen - Plants grow poorly and usually are light-green in color. Leaves turn yellow or light brown and the stems are short and slender. In strawberries, older leaves may develop a red color at the leaf serrations.

Phosphorus - Young leaves are bluish-green with purple tints. The lower leaves sometimes turn light bronze with purple or brown spots. Shoots are short and thin, upright and spindly.

Potassium - Plants have thin shoots. Dieback may occur in severe cases. Older leaves may show slight chlorosis with typical browing of the tips, scorching of the margins and many brown spots, usually near the margins. Leaves may gradually roll upward and inward.

Magnesium - Older leaves are thin. The younger ones become mottled or chlorotic, followed by reddening and sometimes the appearance of necrotic spots. The tips and margins of leaves may turn downward and inward so that the leaves appear cupped. Defoliation may follow.

Calcium - Young leaves become distorted with the tips hooked back and the margins curled. New leaves may fail to unroll. Often the leaves are irregular in shape and ragged with brown scorching or spotting at the margins. Terminal buds eventually die if the deficiency is severe. Affected plants have poor root systems.

Sulphur - Plants have pale green or light yellow colored young leaves without spot formation. Symptoms may resemble those of nitrogen deficiency.

Boron - Bases of young leaves of terminal buds become light green and finally break down. Stems and leaves become distorted. Fruit may crack on the surface or rot in the center.

Zinc - Leaves may initially show interveinal chlorosis, then later develop necrotic areas and show purple pigmentation. Leaves are few and small, with short internodes. Poor fruit production is a common symptom of zinc deficiency.

Manganese - Leaf symptoms are similar to copper deficiency except that small leaves are apt to become crinkled. This deficiency is most common on high pH soils.

Copper - Younger leaves become pale green with red areas between the veins. A pronounced red discoloration may develop in the stems and leaf petioles of strawberries.

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IRON DEFICIENCY IN PLANTS

GENERAL

Under certain soil conditions, iron deficiency may occur in fruit trees, ornamentals and other plants. Although iron is the most abundant of the trace elements, the availability of iron in the soil may be low. As yet there is no suitable soil test for iron, as there is for the major nutrients. Diagnosis of iron deficiency, therefore, rests on identifiable plant symptoms plus a knowledge of the history of the soil.

FACTORS ENCOURAGING IRON DEFICIENCY

- Excess lime in the soil, "lime-induced chlorosis"
- High soil pH (above 8.0)
- Bicarbonate ions in the soil or irrigation water
- Excess amount of phosphates in the soil
- Excess soil moisture and low soil temperatures
- Excess quantities of metallic ions such as copper and manganese which may occur in acid soils

SYMPTOMS

Iron deficiency is characterized by chlorosis (yellowing) of the younger leaves of many species. The tissue between the veins gradually turns yellow while the veins tend to stay green. The conditions may advance throughout the entire plant if unchecked and the tips and margins of some leaves may turn brown and become dry and brittle. In severe cases and with certain species, the new leaves may lose all their green color and appear straw-colored.

Plant species vary in their susceptibility to iron deficiency:

Susceptible
Raspberry
Mountain Ash
Spiraea
Apple
Currant
High Bush Cranberry
Elder

Relatively Tolerant
Russian Olive
Lilac
Cotoneaster
Spruce
Barberry

IRON DEFICIENT LEAVES

Network of veins usually retain their green color while areas between veins become chlorotic.

Conifers such as pine, fir and juniper are less susceptible but may show general needle yellowing on the upper or youngest clusters. Iron deficiencies rarely occur in forage grasses or legumes. Cereal crops may show an intervenal chlorosis or striping along the leaf. Lawn grasses may occasionally show iron deficiency because of high pH or high levels of lime or phosphate in the soil.

AREAS AFFECTED IN ALBERTA

Although iron deficiency may occur in localized areas throughout the province depending on the factors noted above, the condition is most likely to show up in susceptible species growing on high lime or calcareous soils. These soils are found mainly in southern Alberta, primarily in the Brown Soil zone. The closer the lime layer to the surface, as in the case of eroded soils, the greater is the likelihood of induced iron deficiency. In southwestern Alberta there is a wide band of high lime soils extending south of Calgary through the Claresholm area to Fort Macleod.

DIAGNOSIS

1. The application of a foliar spray of an iron-containing compound may be the best means of verifying the diagnosis (see below).

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2. Soil tests specifically for iron are not recommended, but they will determine factors such as pH and lime content which might be affecting the availability of iron to plants.
3. Plant analysis for iron content is of limited value. Soil dust on the sample may be a serious source of iron contamination. Also, plants showing iron chlorosis induced by high levels of phosphorus generally have a normal concentration of iron in the tissues. Such iron, however, does not appear to be readily available to the plants.

TREATMENT

Soil treatments for iron deficiency are not always successful since the same factors that limit the availability of soil iron also render added iron unavailable to plants. The use of foliar sprays and chelated iron compounds, however do offer some promise. When deficiencies exist, iron-chlorotic leaves should begin to "green-up" within ten days after application of iron.

In the case of greenhouse crops particularly, proper adjustment of the pH of the growing medium is often the best preventive treatment. For example, azaleas are grown in a medium-high acid peat which helps to ensure the availability of iron to meet the high iron requirement of these plants.

Soil Application of iron salts, particularly on calcareous soils, is not recommended unless chelated products are available. The chelate resists efforts in the soil to render its iron unavailable to plants.

For trees and shrubs, soil application is most effective if the chelate is applied to the soil and watered in around the base. For potted plants the iron may be dissolved in water and applied as a soil drench.

Iron compounds may be purchased from garden supply centres. A range of package sizes is available. The iron may be in chelate or micronized form and varies in concentration from product to product. As a result of this, general application rates cannot be given here. Purchasers should follow the information supplied on the product label.

Foliar Sprays of iron salts have been used successfully. A 1–2% solution of ferrous sulfate (0.5–1 kg per 45 L of water) may be applied to iron deficient plants. One litre per 20 square metres, or on a field scale, 170–225 L per acre should be adequate. The addition of a wetting agent: i.e. several drops of a mild detergent per gallon is essential.

Iron chelates can also be used in foliar sprays instead of soil applications.

CONCLUSIONS

It should be noted that foliar applications of any iron compound bring about temporary correction of iron chlorosis in a plant, but only by correcting the soil conditions responsible can permanent recovery ever be obtained.

The most practical solution to "lime-induced" chlorosis is learning to live with it and to recognize that a causative factor that induces lime chlorosis may not easily be removed once it is established in a soil. This means that steps should be taken to alleviate, not aggravate, the condition and plant species should be selected which are resistant to iron chlorosis.

Metric Conversion

1 pound X 0.45 = 1 kg
1 gallon X 4.5 = 1 litre
1 square foot X 0.09 = 1 square metre

DISEASES OF STRAWBERRIES

Black Root Rot

CAUSES: Soil fungi (primarily *Pythium*, *Fusarium* and *Rhizoctonia*) nematodes, winter injury, root weevils, herbicide or fertilizer burn, drought, excessive water or salt (alkali) in the soil. Several of these casual agents may act together in certain situations.

SYMPTOMS: Black root rot is a general name for several root problems that produce similar symptoms. Injured plants may be scattered through the planting or grouped in one or more parts of it. To be able to differentiate the symptoms of this disease from the appearance of a normal root, one should be familiar with the features of a developing root. Young main roots of a healthy plant are pliable and almost white. After several months, they usually become woody and turn a dark-brown to black color on the surface. Below the dark surface layer, the yellowish-white tissue of the root core can be seen. Smaller feeder roots branching out from the main roots are white as long as they are living and active.

Plants with black root rot generally have much smaller root systems than normal. Main roots may show patches or zones that are darker than the rest of the root. Small feeder roots may show a similar patchiness or be entirely lacking. Tips or major sections of main roots may be killed, and in cross section they show a black color throughout. Foliar growth is often stunted and reduced and fewer runner plants are produced. Leaves often show marginal burning and fruits are usually small and leathery with prominent seeds. Plants with severe black root rot may die outright or winter kill.

SOURCES OF INFECTION: The *Pythium*, *Fusarium* and *Rhizoctonia* fungi and nematodes are soil borne. Root weevils move about freely as adults.

CONTROL:

1. Select and plant only hardy and healthy plants with well-developed root systems.
2. Plant in a seedbed that has not grown strawberries for 3-4 years. Rotate strawberries with grass or legume crops.

3. Create optimal growing conditions by providing adequate water, fertilizer and insect control measures.
4. If available planting space is limited, seedbeds can be disinfected by fumigating with Vorlex or Vorlex-CP.
5. Plant in a soil that is well-drained and relatively non-saline. If necessary, improve drainage by subsoiling between rows.

GRAY MOLD

PATHOGEN: *Botrytis cinerea*

SYMPTOMS: Gray mold is a very common and often serious disease of strawberries. Blossoms, blossom stalks, and green and ripe fruit may be attacked. Infection usually starts in young blossoms which are very susceptible. Several blossoms in a cluster may turn brown, dry up and eventually the entire blossom stalk dies. Some blossom infections spread only as far as the calyx or hull where the fungus remains dormant until the fruit ripens, at which time a fruit rot will occur. Under humid conditions, an abundance of light gray spores are produced on infected plants. These are easily dislodged and spread by wind currents. Ripe fruit is very prone to infection and the fungus spreads rapidly between berries that are in direct contact in a cluster. Gray mold may not appear on ripe fruit until 1-2 days after picking. The disease is favored by shade and dense foliage where air circulation is poor and sustained periods of high humidity occur.

SOURCE OF INFECTION: Spores are responsible for spread of the disease during the growing season. The fungus overwinters as small dark sclerotinia on various types of vegetative debris in the soil. *Botrytis* has a wide host range, and other crops with gray mold are potential sources of infection for strawberries.

CONTROL:

1. Avoid over-fertilization with nitrogen and other cultural practices which favor the development of excessive foliage.
2. Pick and pack only sound fruit.
3. Apply protective fungicides such as captan, thiram, benomyl (Benlate) + captan, anilazine (Dyrene) or folpet (Phaltan) when blossoms open and repeat as long as control is required. Preharvest intervals - 1 day (folpet), 3 days (thiram), 5 days (anilazine), 7 days (captan, captan + benomyl).
4. Plant mold-tolerant varieties, if available.

LEAF SPOTS

PATHOGENS: *Mycosphaerella fragariae* and *Diplocarpon earliana*

SYMPTOMS: Both diseases are caused by fungi which attack only strawberries. Spores infect the undersides of leaves but spots become visible on the upper surfaces within a few weeks. Moist, warm weather favors the development of both diseases and, as long as these conditions persist, infection will occur. Luxuriant, succulent foliage is usually the most susceptible to leaf spotting.

M. fragariae - Leaves, petioles, fruit and fruit stems may be infected, but the disease is most serious on the leaves. Circular white spots 1-3 mm in diameter may be abundant on affected leaves. Some fruits may be abnormally developed and show a black seed condition.

D. earliana - This is primarily a leaf disease but petioles and fruit stems may also be affected. Initially, small purple spots 1 mm in diameter appear on the upper surface of leaves. These may gradually enlarge into dark blotches which can cause leaves to have a scorched appearance.

SOURCE OF INFECTION: Both fungi produce fruiting bodies within the leaf spots. These contain spores which are discharged in the spring and carried by wind and rain to healthy foliage. Leaf spot diseases are often brought into a field when new plants are set out. Overwintering occurs on dead or live leaf tissue.

CONTROL:

1. Remove and destroy infected foliage after harvest to reduce the amount of overwintering inoculum.
2. Plant varieties with tolerance or resistance to leaf spot diseases.
3. Select disease-free planting stock.
4. Apply fungicides such as dodine (Cyprex), captan, anilazine (Dyrene), folpet (Phaltan) or tribasic copper sulphate when leaves are fully expanded. Treatments may have to be repeated at 10-14 day intervals until harvest if conditions for disease are especially favorable. Preharvest intervals - 1 day (folpet, tribasic copper sulphate), 5 days (anilazine), 7 days (captan, dodine).

PHYSIOLOGICAL ABNORMALITIES

CAUSES: Frost damage, inadequate pollination, hereditary characteristics, drought, and adverse soil conditions.

SYMPTOMS:

Frost - Plants are the most susceptible at full bloom. At temperatures of -3°C severe injury to open flowers, buds and developing berries will occur. Damage to flower pistils prevents pollination and misshapen berries are produced. Since strawberry flowers generally open over a period of several weeks, complete crop losses from frost are usually rare.

Inadequate pollination - Maximum yields and fruit size are achieved when abundant pollinating insects are present. In the absence of insects, berries tend to be small and are frequently malformed. Stamens of primary flowers may not form well during the cool weather of early spring, thereby creating a shortage of pollen. In such cases, large numbers of pollinating insects are needed to ensure a good fruit set. The careless application of insecticides during blooming could seriously reduce populations of pollinating insects.

Hereditary characteristics - "June yellows" is a serious genetic abnormality in which leaves initially show a light yellow streaking and mottling, followed by a complete change to yellow. Affected plants are stunted, unproductive and may finally die. With the arrival of hot weather, the yellow color gradually disappears and the leaves become a normal green. The same cycle of symptoms may be repeated in successive seasons if the plants survive. All runner plants from an infected mother plant also show the disease.

Drought - First or second year plantings seem to be the most susceptible. The tips of leaflets unfolding from the crown may be brown or, in severe cases, whole leaflets may die. Leaflets with dead tips have a pinched appearance when expanded. Tip browning tends to be more prevalent in vigorous plantings during hot, dry periods when soil moisture may be limited. The condition is rarely serious.

Adverse soil conditions - Plant stunting, yellowing and poor production may result under conditions of high salinity, waterlogging or herbicide injury.

CONTROL:

1. Maintain vigorously growing stands by providing optimum fertility, soil moisture and pest control.
2. Provide honeybees for pollination if indigenous pollinating insects are lacking.
3. Rogue out plants showing "June yellows" and replace with healthy stock.
4. Mulches between rows may aid in water conservation.

POWDERY MILDEW

PATHOGEN: *Sphaerotheca macularis*

SYMPTOMS: Infected leaves turn purple and curl upwards exposing undersides which are coated with a dusty, grayish-white fungal growth. Severely affected leaves may wither and die. The disease often appears shortly before fruiting and can seriously reduce marketable yields. Warm, dry weather accentuates the symptoms of powdery mildew.

SOURCE OF INFECTION: The fungus spreads by airborne spores. It overwinters on diseased strawberry debris.

CONTROL:

1. Collect and destroy debris from diseased plants.
2. Apply protective fungicides such as benomyl (Benlate), benomyl + captan, or wettable sulphur. Initiate sprays when new leaves are fully expanded and repeat at 10-14 day intervals, if necessary. Lime sulphur may be applied in the spring when growth starts and again 3 weeks after harvest. Preharvest intervals - 1 day (sulphur, benomyl), 7 days (benomyl + captan).
3. Control red spider mites and harmful insects.
4. Plant mildew-tolerant varieties, if available.

VIRUSES

PATHOGENS: Green Petal, Mottle, Yellows (yellow edge), Veinbanding, Crinkle, Leaf Curl, Witches' Broom and Aster Yellows.

SYMPTOMS:

Green Petal - Flower petals are dwarfed and pale green colored. If berries form, they are dark green with prominent seeds and do not ripen. New leaves are dwarfed and pale green or yellow in color. Infected plants sometimes die late in the season.

Mottle - Tissues between the veins on younger leaves characteristically show an irregular yellowing. Some vein clearing also occurs. Leaves are sometimes puckered or curled and plants may be stunted. Severe strains may markedly distort leaves and flowers.

Yellows (Yellow Edge) - The main symptom is yellowing of leaf margins. Leaves may be stunted and curl and cup upward. Petioles are short, giving plants a compact habit. Autumn reddening usually appears earlier.

Veinbanding - Narrow yellow bands develop along the main and secondary veins. Vein clearing, leaf twisting, shortening of petioles, rugosity and faint yellowing also may be seen.

Crinkle - Mild and severe strains of virus are known. Mild crinkle is characterized by the appearance of numerous small yellowish spots scattered irregularly over the leaf. On young leaves, the spots are small but they gradually enlarge as the leaves expand. With severe crinkle, the initial symptoms resemble those of mild crinkle, but later the yellow tissues turn reddish-brown. Vein clearing, leaf crinkling, petiole stunting and a pale green color are often seen. Infected plants rarely die but they are non-productive.

Leaf curl - Leaves curl up at the edges. Diffuse bands of yellow color occur on leaves and may, in severe cases, turn brown.

Witches' Broom - Leaves are much smaller than normal and are borne on long, spindly, erect petioles. Some leaflets arch and cup downwards and are turgid and somewhat crinkled. The foliage is a light to olive green color. Plants

assume a bushy appearance due to the large numbers of stems and leaves produced from many branched crowns. Runner internodes are short and flower clusters tend to be few and unfruitful.

Aster Yellows - Flower parts are transformed into miniature green leaves forming a gall or tight rosette of dwarfed foliage. Other symptoms are vein yellowing, a general pale green, yellow or reddish color to the foliage, upward cupping of leaflets, curving and twisting of petioles and an upright, stiff, brittle type of growth. Affected plants may die.

SOURCE OF INFECTION: Diseased plants used for sets are a major source of viruses in plantings. Most virus diseases are spread to the runner plants through the sap stream. Insect vectors, chiefly aphids and leafhoppers, spread viruses from plant to plant. Clover phyllody disease, when spread by insects to strawberries, causes green petal. Other viruses may also be spread to strawberries from alternate hosts in nature.

CONTROL:

1. Plant certified, virus-free stock.
2. Rogue out plants with obvious symptoms of virus diseases, including runner plants.
3. Avoid growing strawberries and clover together, or other host combinations known to be deleterious.
4. Control insect vectors, especially aphids.

DISEASES OF RASPBERRIES

ANTHRACNOSE

PATHOGEN: *Elsinoe veneta*

SYMPTOMS: Red raspberries are less seriously affected by this disease than black raspberries. It can attack all above-ground plant parts. Small, circular, slightly raised purple spots appear on young canes in midsummer. The spots may enlarge up to 7 mm in diameter and turn a buff to gray color in the centers with purple margins. If the spots are numerous, several may run together and cover large portions of the cane. The bark may crack in affected areas. Fruits, leaves and flowers may also develop small gray spots. Some leaves may show "shot hole" symptoms if the spots fall out. Infected green fruits fail to mature and dry up, while ripe fruits turn brown and soft.

SOURCE OF INFECTION: The fungus overwinters on diseased canes. Spores are produced in the spring and spread by rain or wind.

CONTROL:

1. Prune and discard old canes after harvest.
2. Plant disease-free stock.
3. Arrange and prune plantings to allow for good air circulation.
4. Avoid excessive use of nitrogen.
5. Apply captan when shoots are 15-20 cm high and repeat at weekly intervals as long as control is required. Preharvest interval - 7 days. Fungicides used for control of spur blight and the bacterial blights will assist in anthracnose control.

CANE BLIGHT

PATHOGEN: *Leptosphaeria coniothryium*

SYMPTOMS: Dark brown to purplish cankers form at wounds (pruning, insect, etc.) on new canes, usually towards the end of the season. As the cankers enlarge and extend down the cane, lateral shoots may suddenly wilt and die. Infection, wilting and death of side branches on second-year canes may occur. Infected canes are brittle and snap off easily. Infected fruiting canes generally die between blossoming and fruit set. Numerous black specks, which are the fungal fruiting bodies, develop in the cankers. In wet weather, spores oozing from the fruiting bodies give cankers a dark gray appearance.

SOURCE OF INFECTION: The fungus overwinters on diseased canes. Spores are wind blown, rain splashed or carried by insects, etc. to healthy canes.

CONTROL:

1. Avoid injuring canes. Control insects and other diseases.
2. Promote good plant growth by using the proper cultural procedures.
3. Prune and burn old canes after harvest.
4. Plant disease-free stock.
5. Use lime sulphur as a delayed dormant spray.

CROWN AND CANE GALLS

PATHOGENS: *Agrobacterium rubi* and *A. tumefaciens*

SYMPTOMS: Crown galls affect the crown and roots of raspberries and blackberries. They can also attack many other woody and herbaceous plants. Red raspberry plants develop galls or knots from the size of a pea to that of a golf ball on the roots and crown. The galls are white at first, turn brown and warty with age, and finally decay. Cane galls appear as small warty outgrowths on the sides of raspberry canes. Plants infected with cane or crown gall may or may not exhibit any reduction in vigor or fruit set.

SOURCE OF INFECTION: The bacteria which incite these diseases may survive for extended periods in the soil. They invade plants only through breaks in the bark and wounds made by insects, pruning and cultivating.

CONTROL:

1. Plant only disease-free stock.
2. Avoid unnecessary injury to plants during cultivation.
3. Control insects.
4. Rogue out badly infected plants, including the roots.
5. Care should be exercised during cane removal and pruning because the bacteria can be spread on the pruning shears. Disinfest pruning shears by soaking momentarily in a 1:5 dilution of household bleach. Fresh bleach solutions should be made up at least every half hour. Other disinfestants which could be used include 50% Lysol at 1:10 or 10% quarternary ammonium compounds at 1:50.
6. When soil has become infested with *Agrobacterium*, susceptible crops should not be planted therein for at least 3 years. Practice crop rotation with non-susceptible crops such as cereals.

FIREBLIGHT AND PSEUDOMONAS BLIGHT

PATHOGENS: *Erwinia amylovora* and *Pseudomonas syringae*

SYMPTOMS: Affected plants display symptoms resembling those of fireblight on fruits and ornamentals. Leaves and blossoms may suddenly turn brown and die. Tips of branches and blossoms clusters are the most commonly affected. Dark-colored cankers may develop on the canes near points of infection through blossoms. Dead canes may crack and curl downwards at the tips.

SOURCE OF INFECTION: Diseased canes may harbor the bacteria over the winter. Ornamentals and tree fruits with fireblight may constitute sources of infection for raspberries. The bacteria are spread by rain splashing, wind, insects and on contaminated pruning shears.

CONTROL:

1. Rogue out infected canes. Disinfest shears between cuts by dipping them into a solution of household bleach (1 part bleach:5 parts water) or undiluted alcohol (e.g., methyl hydrate of isopropyl alcohol).
2. Plant only disease-free stock.
3. Remove nearby plants which are sources of fireblight, or control the disease on these plants.
4. Avoid over-fertilization with nitrogen.
5. Protective sprays of Bordeaux mixture (10:10:100) or copper oxychloride may assist in control. Apply the first spray at the delayed dormant (bud-bursting) stage and repeat at 14-day intervals to thoroughly wet canes. Up to three sprays may be necessary. Preharvest interval - 1 day.
6. Don't prune canes too early in the autumn. Resumption of plant growth following summer drought may result in the production of susceptible growth in autumn.

GRAY MOLD

PATHOGEN: *Botrytis cinerea*

SYMPTOMS: This disease can be very destructive in wet season in plantings where growth is dense. Developing and mature fruits are the most susceptible plant parts. Young canes may wilt and die if infection is severe. When humidity is high, a soft gray fungal growth may cover infected fruits and shoots. In the fall, small dark-colored sclerotia form on infected canes just below the bark or on infected berries.

SOURCE OF INFECTION: The fungus is spread by wind-blown spores, and sclerotia on infected tissues carry it over winter.

CONTROL:

1. Prune and destroy severely infected canes.
2. Avoid bruising fruit when picking or handling canes.
3. Don't over-fertilize with nitrogen and keep canes thinned out to promote good air circulation.
4. Apply protective fungicidal sprays using anilazine (Dyrene), captan, or benomyl (Benlate) + captan when blossoms first open. Apply at 7-10 day intervals for at least three sprays. Preharvest interval - 5 days (anilazine), 7 days (captan, benomyl + captan).

PHYSIOLOGICAL ABNORMALITIES

CAUSES: Winter injury, drought, poor drainage, sunscald, nutrient deficiencies and adverse weather during the growing season.

SYMPTOMS:

Winter injury - This can be a severe problem in certain Chinook-affected areas. Fruiting canes usually produce blossoms but berries fail to develop. If berries develop, they may dry up before ripening. Canes may die after leafing out. Tip dieback frequently occurs.

Drought - Plants appear wilted and unthrifty. Fruit set and yield are poor.

Poor drainage - Roots fail to develop and plants become weak. Root rot diseases may follow.

Sunscald - This problem often develops on ripening fruit during hot sunny weather. Exposed surfaces become discolored at first then later turn to grayish-white patches.

Crumble berry - Thsi disorder is distinguished by a small number of drupelets and crumbly ripe fruit at picking time. Crumble berry tends to be prevalent in plantings where virus diseases are common. Other factors which may influence the occurrence of this disease include nutrient deficiencies, varietal traits, diseases, and lack of pollination.

CONTROL:

1. Winter injury
   - plant only winter-hardy varieties.
   - avoid excessive water applications during the fall hardening-off period.
   - plant a cover crop between rows in the fall to trap snow.
   - choose a shelterbelt site for plantings.
   - avoid fertilizing, cultivating or pruning in late summer as this will stimulate succulent growth.
   - provide winter cover by bending the canes and covering the tips with soil.
2. Drought
   - provide adequate moisture especially during the blossoming and fruiting periods.
3. Poor drainage
   - improve natural drainage by using ditches or tiles. Subsoiling may also help.
   - avoid locating plantings in low-lying areas which are prone to prolonged flooding.

4. Sunscald
   - control insects and leaf diseases which may cause leaf thinning or premature defoliation.
5. Crumble berry
   - keep plants disease-free.
   - provide optimal conditions for growth, e.g., fertilizer, water, etc.
   - avoid planting varieties which appear to be very prone to crumble berry.
   - ensure adequate pollination by providing honeybee colonies where necessary.

POWDERY MILDEW

PATHOGEN: *Sphaerotheca macularis*

SYMPTOMS: Leaves develop a powdery, white fungal growth, particularly on the undersides. Young canes may become stunted, distorted and spindly. Some leaves may develop yellow areas that can be mistaken for mosaic virus. Warm, dry weather favors this disease.

SOURCE OF INFECTION: The fungus spreads by airborne spores. It overwinters on diseased leaf debris.

CONTROL:

1. Apply sprays of benomyl (Benlate) + captan when first blossoms open and at weekly intervals until all the fruit is set. For control after harvest, apply benomyl three to four times at intervals of 14 days, starting at the first signs of the disease. Lime sulphur applied as a dormant spray for spur blight control will also control powdery mildew. Preharvest interval - 7 days (captan, captan + benomyl).
2. Collect and destroy infected plant debris, if practical.

SPUR BLIGHT

PATHOGEN: *Didymella applanata*

SYMPTOMS: This is a common and damaging disease of red raspberries. Weakened plants often have a reduced yield and may winterkill. Purplish to chocolate brown spots and bands appear on young canes directly below the points where the leaves are attached. The diseased areas often enlarge and girdle stems, and may spread to buds, petioles and leaves. Leaves may fall prematurely, especially on lower portions of the plant. Infected bark may dry out and crack by late summer and small pimple-like reproductive structures of the causal fungus may form.

SOURCES OF INFECTION: The fungus survives from season to season on infected plant parts. Spores are produced during wet periods and spread by wind or rain. Infection occurs through healthy or wounded tissue.

CONTROL:

1. Keep rows spaced 45-60 cm apart and prune well to allow for good air circulation.
2. Plant healthy stock.
3. Prune out and burn old canes after harvest.
4. Avoid excessive use of nitrogen fertilizer.
5. In early spring, when the buds show 1-1.5 cm of green tissue, spray with DNOC liquid (Elgetol) or Lime Sulphur. All sides of canes must be thoroughly wetted. Timing is critical as fungi on dormant canes are resistant to the fungicides and spraying unfolded leaves may cause injury. Use captan or ferbam as pre-bloom sprays, if necessary. Captan may be used after blooming, if required. Preharvest intervals - 7 days (captan).

VERTICILLIUM WILT

PATHOGEN: *Verticillium albo-atrum*

SYMPTOMS: This disease is particularly damaging to black raspberries. Leaves on infected canes turn yellow, wither and fall. Lower leaves generally show these symptoms first. The wilt progresses up the canes and they eventally darken in color and die. Wilt symptoms may appear suddenly with the onset of warm, dry weather.

SOURCE OF INFECTION: The *Verticillium* fungus may live in the soil for several years. It attacks through the roots. Poor soil drainage and cool, wet weather favor the disease.

CONTROL:

1. Select a well-drained, wilt-free site for plantings.
2. Do not plant raspberries after tomatoes, eggplants, peppers, strawberries, potatoes, melons, beets or peas.
3. Dig out and destroy infected plants.

VIRUSES

PATHOGENS: Raspberry Mosaic and Leaf Curl Viruses

SYMPTOMS: Raspberries may suffer serious damage from virus diseases, causing yields to fall off sharply. Once infected, plants remain diseased for life and suckers or tips propagated from these are also diseased. Raspberry viruses are spread by aphids and not by mechanical means. Virus-like symptoms may be produced by frost, insects, powdery mildew, nutrient deficiencies or genetic abnormalities.

Mosaic - This is the most widespread virus disease of raspberries. Symptoms are most evident during cool weather. The tissue along the leaf veins becomes yellowish and mottled. Leaves may pucker and curl downward at the edges. Canes tend to be short and weak. During the summer, developing leaves may be symptomless or show a faint mosaic pattern with yellow flecks. Fruit yields may be poor with the berries being dry, seedy and lacking flavor. Black and purple raspberry varieties are usually damaged more severely than red ones.

Leaf Curl - This disease is less common than mosaic. Plants may show only a slight down-curling of tip leaves during the season when infection occurs. The next year, leaves at branch tips appear rounded, dwarfed and crinkled with the margins being curled tightly downward and inward. Fruiting laterals are numerous, short and grow rather upright. Plants remain stunted, weak and may winterkill. Fruit on infected plants is small, hard and crumbly. Black, purple and red varieties are all susceptible to Leaf Curl Virus.

SOURCE OF INFECTION: The viruses spread from diseased to healthy plants by aphids. The pathogens overwinter in diseased canes.

CONTROL:

1. Maintain strict aphid control.
2. Separate black and red raspberry plantings by 50 m to reduce the chances of virus cross-infection.
3. Plant healthy, virus-free stock.
4. Rogue out infected plants.
5. The variety Chief has some tolerance to mosaic.

DISEASES OF CURRANTS AND GOOSEBERRIES

CLUSTER CUP RUST

PATHOGEN: *Puccinia caricina*

SYMPTOMS: Cluster cup rust may appear on cultivated currants, although it tends to be more common on wild currant plants. The disease develops early in the summer and can be distinguished by the clusters of bright, orange-colored cups on the underside of the leaves. Surrounding the cups are swollen reddish areas. Young twigs and fruit may also be infected.

SOURCE OF INFECTION: Cluster cup rust passes the winter on various sedges from which spores are wind-borne to currants in the spring.

CONTROL:

1. Since this rust is usually not serious on cultivated currants, control measures are seldom necessary. In cases where infection is persistent or severe, apply sprays of sulphur as recommended for powdery mildew.

CORAL SPOT

PATHOGEN: *Nectria cinnabarina*

SYMPTOMS: Coral spot is occasionally seen on currant bushes where it causes cankers and dieback. The causal fungus produces conspicuous pink to orange-red cushions (1-3 mm in diameter) on infected stems. These are spore-producing structures.

SOURCE OF INFECTION: The causal fungus can overwinter on branch and twig cankers of currants, gooseberries and many species of woody ornamentals.

CONTROL:

1. Stems exhibiting symptoms of coral spot should be pruned and burned to minimize the risk of spread. This measure is generally sufficient to hold the disease in check.

POWDERY MILDEW

PATHOGEN: *Sphaerotheca mors-uvae*

SYMPTOMS: Powdery mildew is the most destructive disease of currants in Alberta. It generally appears in early summer as a powdery white growth on the youngest leaves. This characteristic appearance results from the production of large quantities of minute fungus spores. These are readily dispersed and, under conditions favoring infection, can attack healthy young growth throughout the season. Later, a slight patchy infection occurs on the leaves. As infection progresses, a felty brown growth develops on the shoots and berries. Cessation of branch elongation and a marked reduction in fruit quality are the consequences of heavy powdery mildew attack.

SOURCE OF INFECTION: The fungus overwinters on infected leaves which fall to the ground. It may also survive in the buds.

CONTROL:

1. Avoid the excessive use of nitrogen fertilizer which promotes succulent susceptible growth.
2. Avoid planting in shaded or partially shaded locations.
3. Prune to maintain an open growth form. Remove weak or crowded branches.
4. Plant resistant varieties:
   Resistant Varieties: White currants - White Grape, Large White, White Imperial; small-fruited American gooseberries - Pixwell; and Albol currants variously referred to as Missouri, California, or cross currants.
   Intermediate: Red currants - Large Knight, Red Lake, Red Cross, Perfection; black currants - Willoughby.
   Susceptible: All European gooseberries and black currants and many North American black currants.
5. Apply lime sulphur at the delayed dormant (green tip) stage. At prebloom, full bloom and early fruit set, apply wettable sulphur. Omit the full bloom spray for currants. Some varieties are sulphur sensitive. Preharvest interval - 1 day.

DISEASES OF SASKATOONS AND CHOKECHERRIES

BLACK KNOT

PATHOGEN: *Dibotryon morbosum*

SYMPTOMS: This disease is common on wild chokecherries. Small, light brown swellings of the current or previous season's growth are the first symptoms observed. The knots may only reach a size of 1-2 cm in diameter. In the spring, knots turn olive green and have a velvety textured surface. By autumn, they turn black and harden and may be 10-15 cm long, completely encircling the limb. The knots continue to expand during successive seasons and may eventually kill the branch. Plums and cherries also may be attacked by black knot.

SOURCE OF INFECTION: The fungus produces spores which are wind-blown or rain-splashed to healthy branches in the spring.

CONTROL:

1. Prune away branches with knots. Cut at least 7-10 cm below the knots.
2. Eradicate infected wild *Prunus* species in the vicinity of orchards or other plantings.

BLACK LEAF AND WITCHES' BROOM

PATHOGEN: *Apiosporina collinsii*

SYMPTOMS: Blackleaf (witches' broom) can infect saskatoons at any stage of growth. Diseased plants show branch proliferation (witches' broom) and the undersides of leaves are covered with a dense black growth (spores) of the causal fungus.

Infection becomes systemic in woody parts and eventually invades all of the new growth, but does not grow back down into older wood.

SOURCE OF INFECTION: Overwintering infections on twigs and branches of saskatoon bushes may resume growth in the spring. The fungus also survives on dead leaves on the bush and on the ground, from which it infects new growth in the spring.

CONTROL:

1. Rogue out infected seedlings, cuttings and root sprouts.
2. On established bushes prune out all twigs, shoots and branches having leaves or witches' broom, about 10 cm below all signs of infection. This may be done in early spring, prior to bud break, but is more easily done in the fall immediately following the main fall of leaves since infected leaves tend to persist.
3. Gather up and burn all infected leaves and prunings. Bushes with infected root crowns must be rogued and burned.

FIREBLIGHT

PATHOGEN: *Erwinia amylovora*

SYMPTOMS: Fireblight is a destructive disease of saskatoons and many other ornamental and fruit plants in the rose family. It occurs sporadically and unpredictably, and occasionally reaches epidemic levels. In the spring, infected blossoms suddenly wilt and turn brown. Later, twigs and leaves also turn brown and appear to be scorched by fire, hence the common name. The affected leaves usually remain on the tree well into winter. Young infected fruits become leathery and turn brown, dark brown or black. The shrivelled fruit usually remains attached to the tree.

SOURCE OF INFECTION: Fireblight bacteria can be spread by wind-driven rain, insects or through pruning. Any ornamental or fruit tree infected with fireblight growing near saskatoons constitute a potential source of infection.

CONTROL: Pruning of diseased twigs and branches is the only effective method of controlling fireblight on saskatoons.

1. During the dormant season (late fall to early spring), prune out and burn all diseased branches. Cut 25-45 cm below the diseased area, because bacteria may extend beyond the blighted portion.

2. During the growing season, prune and burn any infected twigs or branches, again cutting 25-45 cm below the infected area. Make regular inspections during the summer to detect and remove new infections, but avoid excessive pruning. Trees that are severely infected, with large cankers on the trunk, should be removed and burned immediately.

WARNING: In order to prevent the infection of healthy tissue, pruning tools should be dipped in a disinfestant solution after each cut, e.g., Lysol at 50 mL/L; household bleach at 100 mL/400 mL water, or undiluted alcohol (e.g., methyl hydrate or isopropyl alcohol).

GRAY MOLD

PATHOGEN: *Botrytis cinerea*

SYMPTOMS: Gray mold occurs primarily as a rot on the ripening fruit of saskatoons. Cool moist weather provides optimum conditions for infection. Initial infection usually occurs on berries which have been damaged through insect feeding, hail or wind thrashing. Over-ripe berries are also prone to attack by *Botrytis*. The fungus can spread throughout the fruit cluster in a relatively short time after infection is established. Under humid conditions, infected berries and pedicels become covered with the felty gray growth (mycelium and spores) of the pathogen.

SOURCE OF INFECTION: Spores produced on infected berries are an important source of infection during the growing season. The fungus overwinters on infected debris from the previous year. Spores produced on these tissues may incite the first infections on ripening berries. *Botrytis* has a wide host range, so spores can also originate from these sources.

CONTROL:

1. Prevent unnecessary injury to developing and ripening fruit.
2. Pick and pack only sound fruit.
3. Avoid over fertilizing with nitrogen as this promotes excessive foliar growth which hinders air circulation through the branch canopy.

JUNIPER RUST

PATHOGEN: *Gymnosporangium* spp.

SYMPTOMS: Juniper rust is a common and often serious disease of saskatoons. Infected leaves and berries develop yellowish-orange spots which are frequently raised in contour. Later in the season, the undersides of leaves and spots on the berry surface may be covered with numerous spiny projections which contain large quantities of spores.

SOURCE OF INFECTION: The spores produced on saskatoons are wind-borne to junipers, the alternate host, where woody galls are formed on the branches. These overwinter and eventually form another spore stage which reinfects the saskatoon.

CONTROL:

1. Removal of all junipers up to a distance of at least 2 km generally reduces disease incidence to a very low level. Where not practical, isolate saskatoons from junipers with as great a distance as possible and monitor both plants for gall formation and rust.
2. If gall formation on junipers is limited to just a few, affected branches can be pruned and destroyed, if practical.

MUMMY BERRY (BROWN ROT)

PATHOGEN: *Monilinia amelanchieris*

SYMPTOMS: Mummy berry is prevalent in many saskatoon plantings, particularly when precipitation is abundant. The fungus causes berry, twig and blossom blights. Infected tissues are discolored and generally exhibit a felty brown mass of fungal growth (spores) during humid periods.

SOURCE OF INFECTION: Dead infected berries ("mummies") usually cling to the trees after the foliage and other berries have fallen. These overwinter and may produce spores the following spring under favorable conditions. Spores are spread mainly by wind and rain.

CONTROL:

1. Remove all mummified berries, all fallen berries and leaves, and infected twigs and pedicels, and burn them.

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Canada Canada
metric métrique

METRIC CONVERSION TABLE

Approximate conversions to metric measures

When You Know	Multiply by	To Find	Symbol
LENGTH			
inches	2.5	centimetres	cm
feet	0.3	metres	m
yards	0.9	metres	m
miles	1.6	kilometres	km
AREA			
square inches	6.5	square centimetres	cm^2
square feet	0.09	square metres	m^2
square yards	0.8	square metres	m^2
square miles	2.6	square kilometres	km^2
acres	0.4	hectares	ha
MASS			
ounces	28	grams	g
pounds	0.45	kilograms	kg
short tons (2000 lb)	0.9	tonnes	t
VOLUME			
fluid ounces	28	millilitres	ml
pints	0.57	litres	l
quarts	1.14	litres	l
gallons	4.5	litres	l
cubic feet	0.03	cubic metres	m^3
cubic yards	0.76	cubic metres	m^3
TEMPERATURE (exact)			
Fahrenheit		Celsius	°C

°F - 32 x 5/9 = °C

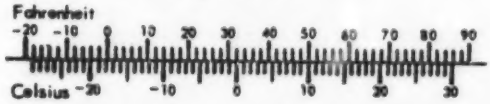

TABLE DE CONVERSION MÉTRIQUE

Conversion approximative aux unités métriques de mesure

Lorsque vous connaissez les mesures en	Multipliez par	Pour obtenir	Symbole
LONGUEUR			
pouces	2.5	centimètres	cm
pieds	0.3	mètres	m
verges	0.9	mètres	m
milles	1.6	kilomètres	km
SUPERFICIE			
pouces carrés	6.5	centimètres carrés	cm^2
pieds carrés	0.09	mètres carrés	m^2
verges carrées	0.8	mètres carrés	m^2
milles carrés	2.6	kilomètres carrés	km^2
acres	0.4	hectares	ha
MASSE			
onces	28	grammes	g
livres	0.45	kilogrammes	kg
tonnes courtes (2000 lb)	0.9	tonnes	t
VOLUME			
onces liquides	28	millilitres	ml
chopines	0.57	litres	l
pintes	1.14	litres	l
gallons	4.5	litres	l
pieds cubes	0.03	mètres cubes	m^3
verges cubes	0.76	mètres cubes	m^3
TEMPÉRATURE (exacte)			
Fahrenheit		Celsius	°C

°F - 32 x 5/9 = °C

Metric Commission **Commission du système métrique**

Simple Conversion Table of Length

Inches	1	2	3	4	5	6	7	8	9	10	11	12
Centimetres	2.54	5.08	7.62	10.16	12.70	15.24	17.78	20.32	22.86	25.40	27.94	30.48 (approx 0.3 m)
Feet	1	2	3	4	5	6	7	8	9	10		
Metres	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0		
Miles	1	2	3	4	5	6	7	8	9	10		
Kilometres	1.6	3.2	4.8	6.4	8.0	9.7	11.3	12.9	14.5	16.1		

Simple Conversion Table of Weight

Ounces (av)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Grams	28.3	56.7	85.0	113.4	141.7	170.1	198.4	226.8	255.1	283.5	311.8	340.2	368.5	396.9	425.2	453.6*
Pounds	1	2	3	4	5	6	7	8	9	10						
Kilograms	0.45	0.91	1.36	1.81	2.27	2.72	3.18	3.63	4.08	4.54						

*(approx 0.45 kg)

Simple Conversion Table of Temperature

Degrees Fahrenheit	0	10	20	30	32*	40	50	60	70	80	90	100	200	212	400
Degrees Celsius	-17.8	-12.2	-6.7	-1.1	0*	4.4	10.0	15.6	21.1†	26.7	32.2	37.8	93.3	100.0	204.4‡

*(Water Freezes)
†(Room Temperature)
‡(Hot Oven)

Simple Conversion Table of Area

Square Inches	1	2	3	4	5	6	7	8	9	10
Square Centimetres	6.45	12.90	19.36	25.81	32.26	38.71	45.16	51.61	58.06	64.52
Square Feet	1	2	3	4	5	6	7	8	9	10
Square Metres	0.09	0.19	0.28	0.37	0.46	0.56	0.65	0.74	0.84	0.93
Acres	1	2	3	4	5	6	7	8	9	10
Square Metres	4 047	8 094	12 141	16 187	20 234	24 281	28 328	32 375	36 422	40 469

Simple Conversion Table of Volume

Ounces (fl.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Millilitres	28.4	56.8	85.2	113.7	142.1	170.5	198.9	227.3	255.7	284.1	312.5	341.0	369.4	397.8	426.2	454.6
Ounces (fl.)	17	18	19	20												
Millilitres	483.0	511.4	539.8	568.2 (approx. 0.57 *l*)												
Pints	1	2	3	4	5	6	7	8	9	10						
Litres	0.57	1.14	1.70	2.27	2.84	3.41	3.98	4.55	5.11	5.68						
Gallons	1	2	3	4	5	6	7	8	9	10						
Litres	4.5	9.1	13.6	18.2	22.7	27.3	31.8	36.4	40.9	45.5						

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